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CANADA'S PRODUCTIVITY IN GOODS PRODUCTION AND SERVICES IN INTERNATIONAL COMPARATIVE PERSPECTIVE

Robert Inklaar, Marcel P. Timmer and Bart van Ark
University of Groningen and The Conference Board

Working Paper 2007-01

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Courriel: mepa.apme@ic.gc.ca

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Abstract

In this paper, we make a comparison of industry output, inputs and productivity growth and levels of Canada relative to six advanced economies [Australia, France, Germany, Netherlands, United Kingdom (UK) and United States (U.S.)]. One of the salient findings is that labour and total factor productivity (TFP) growth in market services accelerated markedly after 1995 in all Anglo-Saxon countries (Australia, Canada, UK and U.S.), in contrast to the Continental European countries (France, Germany, Netherlands) where this sector remained relatively stagnant. While labour productivity growth in Canada slowed down after 2000, the contribution from market services remained high, with most of the slowdown occurring in goods-producing industries. Market services are also the main factor driving differences in TFP levels relative to the U.S. While productivity levels in goods-producing industries are comparable in Canada relative to the U.S., the level in market services is considerably lower. This is also the case in Australia and the UK, while the Continental European countries are on a par with the U.S.

Key words: productivity level, productivity growth, ICT use, multi-country comparisons

Résumé

Les auteurs comparent la production, les facteurs de production ainsi que les niveaux et la croissance de la productivité des industries au Canada par rapport à six économies avancées (Australie, France, Allemagne, Pays-Bas, Royaume-Uni et États-Unis). L'une des principales constatations des auteurs est que la croissance de la productivité du travail et de la productivité totale des facteurs (PTF) sur le marché des services s'est fortement accélérée après 1995 dans tous les pays anglosaxons (Australie, Canada, Royaume-Uni et États-Unis) contrairement aux pays de l'Europe continentale (France, Allemagne, Pays-Bas), où ce secteur a relativement stagné. Bien que la croissance de la productivité du travail ait ralenti au Canada après 2000, la contribution du marché des services est restée élevée, le ralentissement étant, en très grande partie, attribuable aux industries de biens. Le marché des services est aussi le principal responsable de l'écart des niveaux de PTF par rapport aux États-Unis. Alors que les niveaux de productivité des industries de biens sont comparables au Canada et aux États-Unis, le niveau du marché des services est beaucoup plus faible. C'est aussi le cas en Australie et au Royaume-Uni, tandis que les pays de l'Europe continentale sont à égalité avec les États-Unis.

Mots clés : niveau de productivité, croissance de la productivité, utilisation des TIC, comparaisons entre plusieurs pays

1. Introduction

There is a large body of studies of productivity growth and comparative levels, e.g. Baldwin *et al.* (2005), Rao *et al.* (2004), Rao *et al.* (2005), Armstrong *et al.* (2002) and Jorgenson (ed., 2004). However, most of these studies have rather exclusively focused on comparisons between Canada and the United States.[1] Obviously, Canada's competitiveness relative to the U.S. is of great importance given that more than 80 percent of exports from Canada go to the U.S.[2] The objective of this study is to extend the productivity comparison to other major countries – Australia, France, Germany, the Netherlands and the United Kingdom. A wider perspective can yield important insights into, for example, the impact of ICT on productivity growth. By providing a broader range of institutional and regulatory settings, the relative performance of the Canadian economy can be more fully appreciated.

In this paper, we show that although productivity growth in Canada is not as high as in the U.S., it still compares favourably to growth in Europe. In particular, market services have been contributing more to labour productivity growth after 1995 than before. This is a common feature of the post-mid 1990s growth performance in Anglo-Saxon countries (Australia, Canada, UK and U.S.) but not in Continental Europe. In addition, the industry-level growth accounts reveal that only part of the increase in labour productivity growth in market services can be traced to higher information and communication technology (ICT) investment. A large part of the acceleration of growth in this sector is due to higher (TFP) growth. Although the origins of this acceleration in TFP growth are hard to track down, there is evidence from, for example, the retail trade industry pointing towards ICT-enabled innovations such as more streamlined supply chain management.[3] However, an important prerequisite for capturing these gains is a regulatory system that enables experimentation with new organizational forms (such as 'big box retailing') as well as flexible labour market regulations. Our results provide (at least circumstantial) evidence that Canada is much better positioned to reap those ICT-related gains than the European countries.

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[1] One of the exceptions is Harchaoui *et al.* (2003), who compare aggregate productivity growth and levels between Canada and Australia.

[2] To be precise, 86% of Canadian exports went to the U.S. in 2003 and 61% of imports came from the U.S. according to the OECD Bilateral Trade Database.

[3] See McGuckin *et al.* (2004).

Our comparison of labour productivity levels for the market economy suggests that Canada lagged about ten percent behind the U.S. and the continental European countries in 1997. This puts Canada about 15 percentage points ahead of Australia and the UK, but behind France, Germany and the Netherlands. For overall GDP, there was no labour productivity gap between Canada and the U.S., but as we argue, a focus on the market economy is more important for understanding the overall competitiveness of the Canadian economy. The gap in labour productivity levels can mostly be traced to lower levels in market services, while in the goods-producing sector (excluding ICT production) of the Canadian economy, productivity is higher than in the other countries. Furthermore, these patterns for 1997 persist up to 2003.

This study argues that, compared to the other countries we analyze, Canada's labour productivity level suffers mainly from a lower level of (TFP) in particular in market services. Furthermore, headline labour productivity growth since 1995, and particularly since 2000, has been more like the growth pattern in Europe than in the other Anglo-Saxon countries. In contrast, growth in the U.S and Australia has been very high since 1995 and has shown little signs of slowing down yet. In contrast to Europe, however, the Canadian growth slowdown is mainly due to an underperformance in non-market services and in goods-producing industries. The continuing resilience of productivity growth in Canadian market services suggests a more enduring basis for future growth.

The paper proceeds as follows. In Section 2 we outline our basic growth and level accounting methodology. In Section 3, the data and results of our growth accounts are presented at the level of three major sectors of the economy. Section 4 briefly introduces our level accounting methodology, followed by a discussion of the level estimates. In the concluding section we summarize our main results, and indicate the areas for future research.

2. Growth and level accounting methodology

The productivity analysis in this study is rooted in the tradition of national accounting, input-output analysis and growth accounting, as pioneered by – among others – Simon Kuznets, Wassily Leontief, Robert Solow, Edward Denison, Zvi Griliches and Dale Jorgenson. Using these techniques macroeconomic and industry and aggregate measures

of output can be decomposed into the contributions of inputs and productivity.[4] In this section we outline the basic growth accounting methodology and discuss how this framework is augmented to account for productivity level differences across countries.

To assess the contribution of the various inputs to aggregate growth, we apply the growth accounting framework as developed by Jorgenson and associates (see, for example, Jorgenson, Ho and Stiroh, 2005). For each industry gross value added (VA) is computed according to a production function f using ICT capital services (K^{ICT}), non-ICT capital services (K^{N}) and labour services (L). Productivity (A) is represented as a Hicks-neutral augmentation of aggregate inputs. The industry production function (industry subscripts are omitted) takes the following form:[5]

$$VA_t = A f\left(L_t, K_t^N, K_t^{ICT}\right) \tag{1}$$

Under the assumption of competitive factor markets, full input utilization and constant returns to scale, the growth of output can be expressed as the (compensation share) weighted growth of inputs and total factor productivity, denoted by A, which is derived as a residual:

$$\ln\frac{VA_t}{VA_{t-1}} = \bar{v}^L \ln\frac{L_t}{L_{t-1}} + \bar{v}^N \ln\frac{K_t^N}{K_{t-1}^N} + \bar{v}^{ICT} \ln\frac{K_t^{ICT}}{K_{t-1}^{ICT}} + \ln\frac{A_t}{A_{t-1}} \tag{2}$$

where $\bar{v}^i$ denotes the two-period average share of input i in nominal value added. Imposing constant returns to scale implies $\bar{v}^L + \bar{v}^N + \bar{v}^{ICT} = 1$. Capital services are defined in (3) as the aggregate of the individual capital stocks weighted by the capital compensation share:

$$\ln\frac{K_t}{K_{t-1}} = \sum_j \bar{v}_j^K \ln\frac{K_{j,t}}{K_{j,t-1}} \tag{3}$$

where $\bar{v}_j^K$ is the two-period average share of asset type j in total nominal capital compensation. For our growth accounts we use ICT capital services, which are calculated by weighting each of the ICT capital stocks by the share of the asset in total ICT capital compensation. Non-ICT capital services are calculated analogously.

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[4] See Schreyer (2001) for a more detailed exposition.

[5] In equations (1) to (5) we drop industry subscripts i for sake of convenience

We define the change in labour composition as the difference between the growth of labour input and the growth of total hours worked:[6]

$$\ln \frac{q_t^L}{q_{t-1}^L} = \sum_h \bar{v}_h^L \ln \frac{L_{h,t}}{L_{h,t-1}} - \ln\left(\sum_h L_{h,t} \Big/ \sum_h L_{h,t-1} \right) = \ln \frac{L_t}{L_{t-1}} - \ln \frac{H_t}{H_{t-1}} \qquad (4)$$

Here L_t is the labour input index, aggregated over the h labour types using labour compensation shares and H_t is total hours worked, summed over the different labour types. By rearranging equation (2) the results can be presented in terms of average labour productivity growth defined as the ratio of output to hours worked, $va = VA/H$, the ratio of capital services to hours worked, $k = K/H$, labour composition and TFP as follows:

$$\ln \frac{va_t}{va_{t-1}} = \bar{v}^L \ln \frac{q_t^L}{q_{t-1}^L} + \bar{v}^N \ln \frac{k_t^N}{k_{t-1}^N} + \bar{v}^{ICT} \ln \frac{k_t^{ICT}}{k_{t-1}^{ICT}} + \ln \frac{A_t}{A_{t-1}} \qquad (5)$$

We name the decomposition in equation (5) an "input decomposition". As we also focus in this paper on the contribution of industries to aggregate labour productivity growth, an "industry decomposition" measures industry contributions to GDP as follows (Stiroh, 2002a):

$$\ln \frac{va_t}{va_{t-1}} = \sum_i \bar{v}_i^{VA} \ln \frac{va_{i,t}}{va_{i,t-1}} + \left(\sum_i \bar{v}_i^{VA} \ln \frac{H_{i,t}}{H_{i,-1}} - \ln \frac{H_t}{H_{t-1}} \right) = \sum_i \bar{v}_i^{VA} \ln \frac{va_{i,t}}{va_{i,t-1}} + R \qquad (6)$$

where $\bar{v}_i^{VA}$ is the two-period average share of industry i in aggregate value added. The term in brackets in equation (6) is the reallocation of hours. It reflects differences in the share of an industry in aggregate value added and its share in aggregate hours worked. This term will be positive when industries with an above-average labour productivity level show positive employment growth or when industries with below average labour productivity have declining employment shares.

Obviously, one can go one step further by combining the input and industry decompositions of industry labour productivity. Labour productivity growth at an aggregate level is then decomposed into input contributions and a reallocation term for each industry:

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[6] This is sometimes referred to as 'labour quality growth' such as in Jorgenson et al. (2005). However, the advantage of the term 'labour composition change' is that it does not imply that workers with lower wages have a lower quality. Instead, positive labour composition change only implies a shift towards workers with higher wages and hence, higher marginal productivity.

$$\ln\frac{va_t}{va_{t-1}} = \sum_i \bar{v}_i^{VA}\bar{v}_i^{L}\ln\frac{q_{i,t}^{L}}{q_{i,t-1}^{L}} + \sum_i \bar{v}_i^{VA}\bar{v}_i^{N}\ln\frac{k_{i,t}^{N}}{k_{i,t-1}^{N}} + \sum_i \bar{v}_i^{VA}\bar{v}_i^{KT}\ln\frac{k_{i,t}^{KT}}{k_{i,t-1}^{KT}} + \sum_i \bar{v}_i^{VA}\ln\frac{A_{i,t}}{A_{i,t-1}} + R \quad (7)$$

In similar fashion, the contribution from industry TFP growth to aggregate TFP growth can be calculated:

$$\ln\frac{A_t}{A_{t-1}} = \sum_i \bar{v}_i^{VA}\ln\frac{A_{i,t}}{A_{i,t-1}} \quad (8)$$

Level accounting

Comparing productivity levels across countries is in many ways analogous to comparisons over time. Under the assumption of a common production function across countries, equations (2) to (8) can be used after replacing time subscripts t and t-1 by country subscripts. Our level accounts differ from the growth accounts in two respects. First, while one typically compares productivity in one year with productivity in the next or previous year, there is no such natural ordering of countries. Therefore the comparison should not depend on the country that is chosen as the base country. There are various index number methods that can be used to make multilateral comparisons. We use the method suggested by Caves, Christensen and Diewert (1982). This index mirrors the Törnqvist index approach used in our growth accounting, but all countries are compared to an artificial 'average' country (AC).[7] This average country is defined as the simple average of all M countries in the set. For example, a multilateral index of capital services in country c is given by:

$$\ln\frac{K_c}{K_{AC}} = \sum_j \bar{v}_j \ln\frac{K_{j,c}}{K_{j,AC}} \quad (9)$$

with $\bar{v}_j = \frac{1}{2}\left[v_{j,c} + v_{j,AC}\right]$, $v_{j,c}$ the share of asset type j in total nominal capital compensation in country c, $v_{j,AC} = 1/N\sum v_{j,c}$ the average compensation share of capital asset j over all countries N and $K_{j,AC} = 1/N\sum K_{j,c}$, the average capital stock. This mirrors equation (3). A comparison between two countries, say Germany and the US, can

[7] In practice this means applying an EKS procedure to the bilateral Törnqvist indices. The results below are expressed by using the U.S. as the benchmark country. It should be stressed that the decompositions of equations (5)-(8) are noticeably less accurate approximations to the underlying aggregator functions for level accounting than for growth accounting.

be made indirectly: by first comparing each country with the average country and then comparing the differences in German and US levels relative to the average country. Similarly, gaps in labour productivity levels can be decomposed by mirroring equation (5):

$$\ln \frac{va_c}{va_{AC}} = \bar{v}^L \ln \frac{q_c^L}{q_{AC}^L} + \bar{v}^N \ln \frac{k_c^N}{k_{AC}^N} + \bar{v}^{ICT} \ln \frac{k_c^{ICT}}{k_{AC}^{ICT}} + \ln \frac{A_c}{A_{AC}} \tag{10}$$

with $\bar{v}$'s the input shares in value added averaged between country c and the average country AC. Analogous to equation (8), the contribution of industry TFP gaps to aggregate TFP gaps between country c and the average country is given by

$$\ln \frac{A_c}{A_{AC}} = \sum_i \bar{v}_i^{VA} \ln \frac{A_{i,c}}{A_{i,AC}} \tag{11}$$

Furthermore, while each country's national accounts presents information about value added at constant prices over time, such data are not available for directly comparing industry value added across countries. As described in more detail below, our starting point is to measure relative prices (PPPs) for gross output at the industry level. In combination with Supply and Use tables, we use these relative gross output prices to implicitly calculate relative value added prices based on the following expression:

$$\ln \frac{P_c^{GO}}{P_{AC}^{GO}} = \bar{w} \ln \frac{P_c^{VA}}{P_{AC}^{VA}} + (1 - \bar{w}) \ln \frac{P_c^{II}}{P_{AC}^{II}} \tag{12}$$

where $\bar{w}$ is the share of value added in gross output averaged between the country and the average country, and the superscripts GO, VA and II denote gross output, value added and intermediate inputs, respectively. The relative value added price levels are used to calculate implicit relative value added quantity indices which are the output measures we use below.

3. Data and results for growth accounting

Data

For the growth accounts in this paper we developed a database on output and labour and capital inputs for seven countries, including Australia, Canada, France, Germany, the Netherlands, the United Kingdom and the United States, for 26 industries covering the

period 1987 to 2003 (see Table A.1).[8] The data on value added and total hours worked are based on the most recent release of the GGDC (2006a) *60-Industry Database*, while the full industry growth accounts are from the GGDC (2006b) *Industry Growth Accounting Database*.[9]

Output is defined as value added at constant prices and is taken from national accounts complemented with measures from industrial and business surveys. Labour input is measured as hours worked defined as the total number of persons employed (including self-employed) times the average number of hours worked. For labour input in each country we distinguish between three and seven types of educational attainment. For our capital input measures we use data on investment in current and constant prices for six asset types. Three assets refer to ICT goods (computers, communication equipment and software) and three to non-ICT goods (transport equipment, other (non-ICT) machinery and equipment and non-residential structures).[10] To estimate capital stocks we use industry-specific geometric depreciation rates for detailed assets in the U.S., provided in Fraumeni (1997), in combination with industry shares of these assets from the BEA NIPA. The deflators for ICT producing manufacturing industries and ICT investment have been harmonised across countries as discussed by Inklaar et al. (2005), except in the case of Canada and Australia which already use constant-quality price indices to a similar extent as the U.S.

The series for the European countries were published earlier by Inklaar et al. (2005), but were revised and updated to 2003 using the same sources and methods as before. For the United States, we have developed an entirely new dataset, which is largely based on the latest releases by the Bureau of Economic Analysis (BEA) of GDP-by-Industry data that cover the period 1947-2004. These data are organized according to the NAICS 1997 classification system and are consistent with the *2003 Comprehensive*

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[8] Together, the four European countries cover about 70 percent of output in the EU-15. See O'Mahony and van Ark (2003) and van Ark and Inklaar (2005) for figures at the aggregate level for all EU-15 countries. The Australian data covers fiscal years running from July to June. Following OECD convention, we allocate data for July 2000 to June 2001 to the year 2000.

[9] All data and more detailed source descriptions are downloadable at www.ggdc.net/dseries.

[10] Residential buildings are not taken into account to allow for a sharper focus on the productivity contribution of business-related assets. Since most of the outputs and inputs of the real estate industry consists of housing and imputed rents from housing we would have to make an adjustment for this. However, it is hard to separate imputed rents from the other output in the real estate sector. Hence we decided to leave the entire real estate industry out of our dataset.

Revision of the National Income and Product Accounts (NIPA). In addition to the GDP by Industry data, we use numerous other sources, most notably industry output and employment data from the BLS, to obtain a complete set of growth accounts. For U.S. investment we used two main sources from the BEA, namely the *1997 Capital Flow Table* and the BEA *Detailed Data for Fixed Assets* with time series for the period 1901-2004. We made substantial adjustments to the U.S. data to fit the ISIC rev. 3 industrial classification, which is the basis of our internationally comparative database.[11]

Data for Canada and Australia were developed specifically for the purpose of this paper. In the case of Canada the new NAICS-based use tables for the period 1961-2001 have been used to construct the output series. These data were extrapolated to 2003 using industry output series.[12] Employment data were drawn mostly from the OECD STAN database (2004 release). Detailed tables on investment by industry and asset tables from Statistics Canada were obtained through Industry Canada. For manufacturing industries, we supplemented those tables with information from the final demand part of the input-output tables. Ho, Rao and Tang (2004, Tables 10-12) provide data on labour composition change for Canada, which were compiled in a broadly comparable fashion to our methodology for the other countries.

Output series for Australia are mainly taken from the national accounts, supplemented by industry surveys. Data on employment are taken from the Australia's labour force statistics. Detailed investment by industry and asset tables are part of the Australian national accounts, and were supplemented with data from manufacturing surveys to distinguish investment by detailed manufacturing industries. Investment in communication equipment was split off from the broader category (electrical and electronic equipment) using input-output tables. For Australia we only had access to information from the national accounts on labour composition change for the aggregate market sector from the national accounts. This rate was applied to each of the individual industries.

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[11] For the U.S., no educational attainment data has been collected for years after 2000, so labour composition change is assumed to be zero for the latest three years.

[12] Industry output series for 2002 and 2003 are at constant prices. Current price data are estimated using producer price indices for most goods-producing industries and the GDP deflator for other industries. The 2002 input-output tables were released by Statistics Canada after we completed the dataset for this paper.

Industry decomposition of labour productivity growth

On the basis of the dataset described above, measures of labour productivity growth and the contribution of individual industries and major industry groups to aggregate productivity growth can be calculated. **Table 1** shows the results of the industry decomposition from equation (6) for the market sector of the economy for the 1987-1995 and 1995-2003 periods.[13] The table shows a large acceleration in productivity growth in Australia, Canada and the U.S. for the market sector as a whole since 1995. Labour productivity growth in France and Germany slowed down substantially, while growth in the Netherlands stagnated. In the UK, growth also slowed down somewhat, but it remained high compared to the continental European countries. Although Canada's growth accelerated substantially compared to the period before 1995, the market economy growth rate is more comparable to that in the Continental European countries than the Anglo-Saxon countries.

For the industry decomposition we present the results for three major industry groups.[14] Firstly, the contribution of ICT production sector, which includes both ICT manufacturing and services, differs between countries.[15] The U.S. and the UK show rather high contributions from ICT producers to productivity growth, whereas the continental European countries take an intermediate position and Australia and Canada show very small contributions. Secondly, the differences in average contributions of 'other' goods-producing industries (excluding ICT producing manufacturing) have been very small since 1995. Of course, there are differences between contributions of

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[13] The exact definition of the market economy (or business sector) differs by country and organization. We classify government (ISIC 75), education (ISIC 80) and health (ISIC 85) as non-market services, even though some or even most of education and health may be operated or owned by non-governmental organizations. The reason for excluding these sectors from the analysis is mainly due to severe measurement problems in these industries. Moreover the international comparability of non-market output measures is very weak, which makes affects the interpretation of differences in growth performance at the total economy level. Table 1 also shows the total economy aggregates, including non-market services and these results were more extensively analyzed in Timmer and van Ark (2005).

[14] Reallocation effects are generally negative, which suggests that industries with an above-average labour productivity level exhibit declining employment shares. In earlier work, such as van Ark et al. (2003), we also distinguished between industries that used ICT intensive and those that did not – based on U.S. estimates of ICT investment relative to total investment. This approach necessitates a somewhat arbitrary distinction that has been criticized by, for example, Daveri (2004). More importantly though is the fact that it has become less important to make this distinction because we now have actual measures of ICT use for countries outside the U.S.

[15] See Appendix Table A.1 for the classification of industries into industry groups.

individual goods-producing industries, but mostly these contributions are positive and small and therefore matter relatively little for the aggregate performance.

Finally, and most importantly, the differences in contributions of market services (excluding ICT services) are quite large between the countries. All Anglo-Saxon countries show accelerations in the contributions from market services to labour productivity growth since 1995, ranging from 0.5 percentage point acceleration in the UK to 1.5 percentage points in Australia. In the U.S., labour productivity in market services increased by 0.9 percentage point from 0.9 per cent per year in 1987-1995 to 1.8 per cent per year from 1995-2003. In the Netherlands market services showed a slight increase in the contribution of 0.2 percentage point, but France and Germany experienced a deceleration of 0.1 and 0.6 percentage point, respectively. Here, the contrast between Canada and the Continental European countries becomes most apparent, as the growth contribution of market services is quite close to that in the other Anglo-Saxon countries.

Input decomposition for market services

Using data on capital services and labour composition, labour productivity growth rates for each industry and industry group are decomposed into contributions from ICT capital deepening, non-ICT capital deepening, labour composition change, TFP growth and reallocation of hours worked (see equation 7). Here we focus exclusively on an input decomposition of labour productivity growth in market services which are the most intensive users of ICT assets. The results are given in **Table 2**. All countries in the table show a moderate to substantial acceleration in the contribution of ICT capital deepening in market services. However, what stands out in Table 2 is the rapid acceleration in TFP growth in market services in the Anglo-Saxon countries (Australia, Canada, UK and U.S.). Before 1995, TFP growth in market services was low or negative in these countries, but turned positive after 1995. In contrast, all Continental European countries (France, Germany and the Netherlands) showed deteriorating TFP growth in market services after 1995. Germany and the Netherlands experienced negative TFP growth in market services after 1995 and France shows only a small positive growth rate.

Table 3, based on equation (8), looks at the contribution of individual service industries to total factor productivity growth in market services from 1995-2003, with a breakdown for 1995-2000 and 2000-2003. The table shows that the strong TFP

performance in Canada occurred in many of the individual industries already before 2000 and growth broadened further after 2000. The higher growth contribution from business services is a common feature in the Anglo-Saxon countries, while in the Continental European countries, this industry made the largest negative contributions.

The precise reasons for the differences in productivity dynamics of market services are difficult to generalize. One possibility is that in some countries investments in ICT do not lead to faster TFP growth whereas in other countries they do. There may be many reasons for this, among which cyclical effects and the effects of unmeasured intangible investments stand out. Estimates of ICT output elasticities that are larger than the marginal cost of ICT capital services would violate a basic growth accounting assumption. However, Inklaar (2005) and van Ark and Inklaar (2005), in line with, for example, Stiroh (2002b), find that industry data do not exhibit supra-normal returns. There is even some evidence that it takes a number of years of below-normal returns before the productive returns of ICT become high enough to outweigh the cost.[16]

The slow uptake of productivity in market services also emerges from studies that take a more industry-specific orientation. For example, McGuckin, Spiegelman and van Ark (2005) analyze labour productivity growth in European and U.S. wholesale and retail trade in detail. They find that technology adoption in Europe lags the U.S. by several years, which has been holding back European productivity growth. They also find that this lag can be (partly) attributed to stricter regulations in European countries.[17] But the explanation for the slowdown since 2000 has so far remained unexplained, and more work in this area (for retail and other service industries) is therefore required.

To shed more light on the reasons for the large differences in the contribution of market services to productivity growth one might focus not exclusively on comparisons of growth rates but also on comparative levels of productivity. For example, rapid TFP growth could point towards catching-up and imitation when starting from a relatively low productivity level. Similarly, stagnating TFP growth at a relatively high level of TFP

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[16] An alternative approach is to directly estimate each of the output elasticities separately. For example, O'Mahony and Vecchi (2005) find super-normal returns on ICT, which they attribute (at least in part) to the returns to unmeasured intangible investment, such as organizational change or training programs. An advantage of their approach is that no assumptions about the other output elasticities have to be made, but the disadvantage is that it requires a rather restrictive functional form for the production function (such as Cobb-Douglas) for the estimation (see van Ark and Inklaar, 2005).

[17] For a more detailed statistical analysis of growth differences in the trade sector, see Timmer and Inklaar (2005).

might be indicative of a lack of innovation. Therefore we turn to level comparisons for the remainder of this paper.

4. Data and results for level accounting

A level accounting approach to output and productivity comparisons has not been widely applied, which is primarily due to the lack of adequate industry-specific PPPs for output and inputs. PPPs are needed to adjust output and inputs for differences in relative price levels between countries. Since there is little reason to assume that these price differences are negligible between countries or the same across industries, such PPPs have to be industry-specific.

Only few studies have attempted to measure industry-specific PPPs. Most comparisons have tended to restrict themselves to the total economy (e.g. Schreyer, 2006). Jorgenson, Kuroda and Nishimizu (1987) make use of specific PPPs for expenditure categories from OECD to measure TFP for about 30 industries between Japan and the U.S. These expenditure PPPs are adjusted for differences in transport and distribution margins across countries. Other studies have aimed to directly measure producer-price based PPPs. Van Ark and Pilat (1993) provided TFP level measures for manufacturing industries in Germany, Japan and the United States using a ratio of unit values which are based on producer quantities and values from production censuses in different countries. Similarly, Timmer (2000) measured TFP for manufacturing in Asian countries using a similar methodology. Pilat (1996), Mulder (1999), O'Mahony (1999), and O'Mahony and de Boer (2002) extended the industry-specific PPP approach to measuring output and productivity levels beyond manufacturing. Most studies had to rely on bilateral comparisons of pairs of countries. It has also turned out to be difficult to develop a consistent PPP methodology across the various studies because of differences in data availability. In particular, value added is often deflated by gross output price relatives, without taking into account differences in prices of intermediate inputs (so-called single versus double deflation).

In this paper we make use of a new and comprehensive dataset of industry PPPs for 1997, in combination with a benchmark set of Supply and Use tables from the relevant statistical offices. PPPs for value added are constructed by double deflation of gross output and intermediate inputs within a consistent input-output framework (see

equation (12)). In addition, relative price ratios for labour and capital input are developed. For a full discussion of the new industry PPPs, the reader is referred to Timmer, Ypma and van Ark (2006). For the integration of gross output PPPs and the derivation of input PPPs in a level accounting framework, details are spelled out in Inklaar and Timmer (2006). Below we only present the most important elements of our methodology.

PPPs for gross output are defined from the producer's point of view and are at basic prices, which measures the amount received by the producer for a unit of a good or service produced. These PPPs have partly been constructed by way of unit value ratios for agricultural, mining, manufacturing and transport and communication services. For other industries, PPPs are based on specific expenditure prices from Eurostat and the OECD, which are allocated to individual industries producing the specific item. The value was adjusted from expenditure to producer level with relative transport and distribution margins and by adjusting for differences in relative tax rates. Margins and tax rates were derived from benchmark supply and use tables for 1997. This set of gross output PPPs for 1997, covering 45 industries at (roughly) 2-digit industry level, has been made transitive across countries by applying the multilateral EKS-procedure for a total of 26 countries, which are all OECD countries but also includes Taiwan). For this study the gross output PPPs were then are allocated to the 26 industries in Input-Output tables for 1997.

Intermediate input PPPs are required in order to double deflate value added. These input PPPs should reflect the costs of acquiring intermediate deliveries, hence they need to be based on purchasers' prices. Assuming that the basic price of a good is independent of its use, we can use the same gross output PPP for a particular industry, after adjustment for margins and net taxes, to deflate all intermediate deliveries from that industry to other industries. The aggregate intermediate input PPP for an industry is then derived by weighting its intermediate inputs at the gross output PPPs from the delivering industries. Imports are separately identified for which exchange rates are used as PPP, hence assuming no price differences across countries for imported commodities.

To obtain PPPs for capital and labour input, we follow the methodology outlined by Jorgenson and Nishimizu (1978). The PPP for capital services is based on the expenditure PPP for investment from Eurostat and the OECD, adjusted for differences in the user costs between countries. The user cost of capital input depends on the rate of

return to capital, the depreciation rate and the investment price change. This data is taken from the growth accounts discussed in the previous section. The procedure to obtain a PPP for labour is more straightforward than for capital as it simply involves aggregating relative wages across different labour types using labour compensation for each type as weights. For this purpose we only distinguish between two labour categories: workers with a university degree or higher, and those without. This limited number of skill types is due to difficulties in matching schooling systems across the various countries.

Industry decomposition of labour productivity levels

The first step in presenting our level results, it to focus on the comparative levels of labour productivity for the same major industry groups (ICT production, other goods production and market services) as in the first part of the paper. **Table 4** shows comparative levels of labour productivity, measured as value added per hour worked. The results for 1997 are for our benchmark year, and developed according to the methodology outlined above.

Table 4 shows that the U.S. labour productivity level in the market economy is similar to that of the three continental European countries, ranging from France at 96 per cent of the U.S. level to the Netherlands at 107 per cent.[18] The other Anglo-Saxon countries show between 10 and 30 percent lower labour productivity levels than the U.S, ranging from Australia at 73 per cent of the U.S. level to Canada at 88 per cent.

Table 4 also shows relative labour productivity levels in ICT production, other goods-producing industries and other market services in 1997. The relative productivity levels in market services correspond most closely to those at the level of the market economy, with productivity levels in France, Germany and the Netherlands relatively close to that of the U.S., while Australia, Canada and the UK are at a large distance from the other countries. Productivity levels in goods-producing industries are generally closer together, with the exception of Canada which has high productivity levels in some

[18] The margin of error around level estimates is non-negligible. Although (formal) research on this issue is limited, Schreyer (2006) arrives at a confidence interval of (at least) 10 percent using a simulation exercise. Strikingly, the relative total economy levels are all higher relative to the U.S. than the market economy levels, signalling high relative TFP levels in non-market services in countries outside the U.S. These differences are largest in European countries, like France and the Netherlands. As before, when dealing with the growth, it is not clear how to interpret the results for the non-market sector given the substantial measurement problems that remain.

resource-intensive and heavy manufacturing industries, like oil refining, metal products and machinery as well as in utilities. The high productivity levels in ICT production in France, Germany and the UK can mostly be traced to communications services, with again smaller differences in ICT manufacturing.

Table 4 also shows an extrapolation of the benchmark results for labour productivity in 1997 to 2003. Starting from the relative labour productivity levels for 1997, we have applied the relative growth between 1997 and 2003 at the aggregate and industry group level (see Table 1).[19] The faster productivity growth in the U.S. since 1997 has resulted in lower productivity levels relative to the U.S. for the other countries, but the cumulative impact is still relatively small over a period of only six years.

Input decomposition of level accounts for market services

The relatively low productivity levels in market services in the Anglo-Saxon economies (except the U.S.) sheds additional light on the possible reasons for rapid productivity growth in the market services sector for these countries, as was observed earlier. Rapid growth might typically be related to catching up-effects as the industries started from low levels of productivity, and benefited from technological progress, innovation and institutional changes – more than the continental European countries which started from much higher levels. To explore this possibility further, an input decomposition of differences in the level of productivity is useful.

Table 5 shows an input decomposition of the labour productivity gap in market services into the contributions of ICT capital intensity, non-ICT capital intensity, labour composition and TFP to the gap following equation (10). For example, the (log) labour productivity gap between Canada and the U.S. is 43 percentage points,[20] of which 9 percentage points are due to lower ICT intensity, 7percentage points to lower non-ICT intensity, 2percentage points due to fewer university-educated workers, and 26 percentage points due to lower TFP levels.

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[19] The data requirements for a level comparison for one year are quite substantial, and in many cases these data only become available with a considerable lag. As a result, a fully consistent level accounting exercise cannot yet be done for a later year than our benchmark year 1997. Extrapolating the 1997 benchmark results forward is also not straightforward since ideally this should be done at most detailed level before re-aggregating using the CCD-method. As the data requirements for such an extrapolation would be comparable to that of a new benchmark, this is also not feasible at the moment.

[20] The gap here is defined as the difference in the natural log of the levels, to stay consistent with the growth accounts and the decomposition formulae which are also in terms of logs.

A number of observations stand out from Table 5. Firstly, ICT capital input per hour worked is higher in U.S. market services than anywhere else, and accounts for between 3 and 10 percentage points of the U.S. labour productivity level advantage. In contrast, non-ICT capital levels are higher in the Continental European countries, and account for the bulk of the productivity advantage in market services for France and Germany. In Germany, higher capital intensity adds as much as 21 percentage points to Germany's advantage relative to the U.S., accounting for more than the total labour productivity gap.[21] This is partly compensated by lower ICT capital intensity and less skilled labour. In the Anglo-Saxon countries, non-ICT capital intensity in market services is lower than in the U.S. Labour composition levels in market services are also below the U.S. levels, with the exception of Canada and the Netherlands where it is relatively close to the U.S. level.

The major factor accounting for the productivity gap between the U.S. and both Canada and the other Anglo-Saxon countries is the lower TFP level in market services in the latter countries. It accounts for between 21 percentage points of the Australian gap relative to the U.S. and 26 percentage points of the Canadian gap. In France and Germany, the TFP level is comparable to the U.S. Only in the Netherlands, the higher productivity level in market services relative to the United States is largely due to a higher TFP level.

Finally, **Table 6** provides an industry decomposition of the TFP gaps in market services relative to the United States. In contrast to the input decomposition of market services in table 5, productivity gaps are now decomposed to the contribution of productivity gaps in the more detailed industries, see equation (11). So, for example, the 26 percentage point TFP gap in market services between Canada and the U.S. is mainly due to the gap in business services, contributing almost 13 percentage points, followed by "other" market services at 6 percentage points.

Most countries have one or more industries where TFP levels are higher than in the U.S., but this is not the case in Canada. However, the differences are comparatively small in industries like wholesale, retail and transport and large in particular in business

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[21] The quality of data on investment by industry and asset as well as the investment PPPs are areas for potential improvement of the results. However, any adjustment would have to be implausibly large to account for the high non-ICT capital intensity level in Germany.

services. High productivity levels in business services seem a uniquely U.S. feature as the gap is of similar size for the other countries.

6. Summary and concluding remarks

In this paper we have analyzed productivity growth and levels in Canada. A first distinguishing point is that we compared Canada not just to the U.S., but also to Australia and four European countries (France, Germany, Netherlands and UK). Second, throughout, we have measured and compared the importance of investment in ICT capital, since this has been one of the main sources of the U.S. labour productivity growth acceleration. Third, as far as analyzing productivity growth, our comparison runs up until 2003, giving a detailed overview of the more recent growth developments. Finally, we have compared productivity levels at the industry level for 1997, the most recent year for which an exercise of this magnitude can be performed. Although bilateral productivity comparisons have been done before (e.g. Lee and Tang, 2002 and Rao *et al.*, 2004 for Canada vs. the U.S), this is one of the first multilateral comparison which is conducted within a consistent input-output framework.

The main findings are that labour productivity growth in Canada has relatively strong roots in an improved performance of market services productivity. Specifically, since 1995, market services in Anglo-Saxon countries have contributed much more to labour productivity growth than in the period before or than in Continental European countries. Furthermore, this can be traced to a combination of strong ICT investment, but more importantly, to strong total factor productivity (TFP) growth. While TFP growth in this sector has been mostly negative in this period in Continental Europe, it has turned strongly positive in each of the Anglo-Saxon countries after 1995. More detailed industry-level work has shown that in the U.S., greater product and labour market flexibility have helped stimulate ICT investment and productivity growth in key services industries, such as retail trade. Strong productivity growth in these sectors suggests Canada is also reaping the benefits of ICT adoption.

However, the level of ICT capital per hour worked is generally much lower in Canada than in the U.S., with smaller gaps compared to the other countries. Again the industry perspective adds valuable insights. The goods-producing sector in Canada has a TFP level that is higher than in Australia and close to that in the other countries. In

contrast, the market services TFP level in Canada is about 25 percentage points lower than in the U.S. and indeed, lower than in any of the countries analyzed.

Extrapolation of the results to 2003 tells a broadly comparable story. We have raised concerns about a too strict interpretation of the level results, as substantive measurement issues remain. It is clear, however, that our results suggest that Canada's current competitive position is relatively strong, since its productivity level in the traded sector is similar or higher compared to that in its main trading partners. However, as technological progress makes it easier to engage in trade in services, it will become even more important to continue strong productivity growth in market services in order to close the relatively large productivity gaps in several market service industries.

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Table 1: Industry Contributions to Market Economy Labour Productivity Growth, 1987-2003 (value added per hour worked, percentage growth and contributions)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
1987-1995							
Market economy	1.1	1.2	2.7	2.8	1.7	2.9	1.9
contributions from:							
ICT production	0.4	0.3	0.4	0.6	0.2	0.7	0.6
Goods-producing industries	1.1	0.7	1.3	1.2	1.2	1.8	0.5
Market services	0.0	0.3	0.7	0.8	0.5	1.0	0.9
Reallocation of hours	-0.3	0.0	0.3	0.2	-0.2	-0.6	-0.2
Total economy	1.3	0.8	2.0	2.5	1.6	3.0	1.3
1995-2003							
Market economy	2.7	2.0	2.0	2.0	1.7	2.7	3.0
contributions from:							
ICT production	0.3	0.2	0.6	0.6	0.4	0.9	0.8
Goods-producing industries	0.8	0.7	0.8	0.9	0.8	0.6	0.7
Market services	1.8	1.3	0.6	0.2	0.7	1.5	1.8
Reallocation of hours	-0.1	-0.2	0.0	0.3	-0.2	-0.3	-0.2
Total economy	2.5	1.9	1.8	1.7	1.5	2.5	2.5

Source: GGDC Industry Growth Accounting Database, see www.ggdc.net for data. See Section 2 and Inklaar et al. (2005) for methods, and Section 3 for source descriptions.

Notes: Market economy includes all industries except real estate (ISIC70) government (ISIC75), education (ISIC80) and health (ISIC85). Labour productivity and TFP contributions are calculated using the share of industry value added in market economy value added. ICT/non-ICT capital contributions are calculated using the share of industry ICT/non-ICT capital compensation in aggregate value added. Labour quality contributions are calculated analogously based on industry labour compensation. Reallocation of hours is the difference between output-weighted industry growth in total hours worked and employment-weighted growth in total hours worked. See Appendix Table A.1 for the classification of industry groups.

Table 2: Input Contributions to Market Services Labour Productivity Growth, 1995-2003 (value added per hour worked, percentage growth and contributions)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
1987-1995							
Market services (excl. ICT services)	0.0	0.5	1.2	1.9	0.8	1.7	1.5
contributions from:							
ICT capital deepening	0.5	0.4	0.3	0.4	0.6	0.6	0.9
Non-ICT capital deepening	-0.2	0.4	0.3	0.6	0.3	0.9	0.3
Labour quality growth	0.3	0.3	0.2	0.2	0.3	0.7	0.3
TFP growth	-0.6	-0.7	0.3	0.4	-0.3	-0.5	0.2
Reallocation of hours	0.0	0.0	0.1	0.4	0.0	0.0	0.0
1995-2003							
Market services (excl. ICT services)	2.8	2.4	0.9	0.9	1.1	2.2	2.7
contributions from:							
ICT capital deepening	0.9	0.5	0.5	0.6	0.9	0.9	1.3
Non-ICT capital deepening	0.1	0.2	0.0	0.3	0.4	0.6	0.4
Labour quality growth	0.2	0.1	0.2	0.0	0.1	0.2	0.1
TFP growth	1.7	1.4	0.1	-0.5	-0.4	0.5	0.9
Reallocation of hours	-0.1	0.1	0.0	0.5	0.0	0.0	-0.1

Sources and notes: see Table 1

Table 3: Industry Contributions to Total Factor Productivity Growth in Market Services, 1995-2003, (percentage growth and contributions)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
1995-2000							
Market services (excl. ICT services)	0.8	1.3	0.3	-0.4	0.2	0.0	0.6
contributions from:							
Wholesale trade	0.3	0.0	0.3	0.4	0.7	0.0	0.9
Retail trade	0.5	0.7	0.0	0.1	0.1	-0.2	0.3
Transport & storage	-0.1	0.2	0.2	0.2	0.2	0.0	0.0
Financial intermediation	0.2	-0.3	0.2	0.0	-0.5	0.1	0.0
Business services	-0.1	0.4	-0.4	-1.0	-0.2	0.0	-0.4
Other market services(a)	0.1	0.3	-0.1	-0.1	-0.1	0.1	-0.2
2000-2003							
Market services (excl. ICT services)	3.2	1.7	-0.1	-0.7	-1.4	1.4	1.3
contributions from:							
Wholesale trade	0.4	0.4	0.2	0.2	-0.1	0.4	0.3
Retail trade	0.0	0.3	0.0	0.3	-0.1	0.2	0.2
Transport & storage	0.7	0.2	-0.2	-0.1	-0.1	0.0	0.2
Financial intermediation	0.0	0.1	-0.2	0.0	-0.1	0.0	0.4
Business services	0.9	0.5	-0.5	-0.8	-0.7	0.6	0.3
Other market services(a)	1.2	0.2	0.6	-0.2	-0.4	0.1	-0.1

(a) Other market services include construction, hotels and restaurants and social & personal services.

Sources and notes: See Table 1

Table 4: Labour Productivity Levels Relative to United States, 1987 and 2003 (value added per hour worked, US=100)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom	United States
1997							
Market economy	73	88	96	103	107	73	100
ICT production	65	89	100	98	73	117	100
Goods-producing industries	82	127	92	89	102	80	100
Market services	68	65	96	113	118	64	100
Total economy	83	98	107	112	122	84	100
2003							
Market economy	71	83	89	92	99	72	100
ICT production	42	59	98	84	68	124	100
Goods-producing industries	78	123	92	85	102	81	100
Market services	69	65	89	102	108	63	100
Total economy	82	95	103	105	115	84	100

Source: 1997: Supply and Use tables for individual countries from Inklaar and Timmer (2006) and PPPs from Timmer, Ypma and van Ark (2006); 2003 updated from 1997 with time series underlying table 1.

Notes: For methodology, see Inklaar and Timmer (2006)

Table 5: Input Contributions to the Gap in Labour Productivity in Market Services, 1997 (value added per hour worked, gap measured as percentage productivity differential relative to the US)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom
Market services (excl. ICT services)	-38.7	-43.2	-3.6	12.3	16.2	-44.1
contributions from:						
ICT capital per hour worked	-9.3	-9.1	-7.4	-3.2	-4.9	-10.1
Non-ICT capital per hour worked	-3.9	-6.8	8.4	21.2	4.0	-7.2
Labour composition	-4.1	-1.6	-6.3	-8.0	-0.6	-4.2
TFP	-21.3	-25.6	1.6	2.3	17.8	-22.5

Sources and notes: see Table 4. The gap is defined as the natural log of the level. The contributions of the different inputs are calculated by multiplying the gap in input level by the share of each input in value added.

Table 6: Industry Contributions to the Gap in Total Factor Productivity in Market Services, 1997 (gap measured as percentage productivity differential relative to the US)

	Australia	Canada	France	Germany	Nether-lands	United Kingdom
Total Factor Productivity						
Market services (excl. ICT services)	-21.3	-25.6	1.6	2.3	17.8	-22.5
contributions from:						
Wholesale trade	-5.0	-1.8	5.1	6.6	7.8	0.6
Retail trade	-2.1	-2.0	3.0	2.9	2.3	-1.5
Transport & storage	-0.4	-0.8	-0.4	-1.7	4.4	-2.2
Financial intermediation	7.4	-1.9	4.6	1.8	6.6	3.4
Business services	-14.5	-12.7	-12.6	-8.8	-9.7	-11.1
Other market services(a)	-6.7	-6.4	1.9	1.4	6.3	-11.8

(a) Other market services include construction, hotels and restaurants and social & personal services.

Sources and notes: see Table 4. The gap is defined as the natural log of the level. The contributions of the different industries are calculated by multiplying the gap in productivity levels by the share of each industry in value added. Due to index number problems, the contributions have to be normalized by distributing the difference between the sum of the contributions and the aggregate according to each industry's share in value added.

Appendix Table A.1, Industry list

Industry	*ISIC rev3 code*	*Group*
Agriculture, forestry and fishing	01-05	PROD
Mining and quarrying	10-14	PROD
Food products	15-16	PROD
Textiles, clothing and leather	17-19	PROD
Wood products	20	PROD
Paper, printing and publishing	21-22	PROD
Petroleum and coal products	23	PROD
Chemical products	24	PROD
Rubber and plastics	25	PROD
Non-metalic mineral products	26	PROD
Metal products	27-28	PROD
Machinery	29	PROD
Electrical and optical equipment	30-33	ICT
Transport equipment	34-35	PROD
Furniture and miscellaneous manufacturing	36-37	PROD
Electricity, gas and water	40-41	PROD
Construction	45	MSER
Wholesale trade	50-51	MSER
Retail trade	52	MSER
Hotels and restaurants	55	MSER
Transport & storage	60-63	MSER
Communications	64	ICT
Financial intermediation	65-67	MSER
Business services	71-74	MSER
Social and personal services	90-99	NMAR
Non-market services	75-85	MSER

Notes: Group shows in which industry group each of the industries is classified. ICT: ICT production, PROD: Other goods-producing industries, MSER: Market services, NMAR: Non-market services.